ITALIAN PETROLOGICAL STUDIES.

IV. THE ROCCA MONFINA REGION.

THE volcano of Rocca Monfina, was long celebrated as one of the classical examples brought forward in favor of von Buch's hypothesis of Craters of Elevation. Its historical interest is equaled by its interest from a petrological point of view, since, apart from the character of the rocks of which it is built up, their order of succession forms an exception to that met with elsewhere among the Italian volcanoes. My visit to the locality was extremely brief and was confined to a trip from Teano on the eastern border, past the central mass of Mte. Sta. Croce to Conca, with one or two short excursions. I must therefore rely for most of my knowledge of the volcano on the work of others — a resource which in this case is somewhat meager.

Rocca Monfina has been in fact one of the most neglected of Italian volcanoes. The early works, chief among which are those of Abich[1] (who gives views and a map), Daubeny[2] and Pilla[3] are devoted to an exposition of their views in favor of von Buch's theory and the examination of the volcano from this standpoint. They are therefore chiefly of historical value, though Abich gives some descriptions of the rocks. Vom Rath[4] devotes a few pages of Part IV of his "Italian Fragments" to a description and analyses of two of the rocks, which we shall have occasion to notice later. A few others are briefly described by J. Roth,[5] and Bucca's descriptions are quoted by Rosenbusch. The only modern writers who deal at all fully with the region

[1] ABICH, Vulk. Ersch. der Erde. Braunschweig, 1841.

[2] DAUBENY, Volcanoes, London, 1848. 174.

[3] PILLA, cf. Neu. Jahrb. 1845, 843, and references in Moderni.

[4] VOM RATH, Zeit. d. d. geol. Ges. 243, 1873.

[5] ROTH, Geologie, II, 245, 275, 354.

are Bucca[1] and Moderni.[2] The former gives petrographical descriptions of the rocks collected by Moderni; and the latter describes the region from a geological point of view, giving a quite detailed geological map on a scale of 1:100,000. Deecke[3] also touches upon the tuffs of the region in an article on the tuffs of Campania.

Topography.— The volcano of Rocca Monfina lies about 70 kilometers northwest of Naples, west of the main railroad line from Naples to Rome. In the center is the trachy-andesitic dome of Mte. Sta. Croce, 1005 meters above sea level, with the smaller similar dome of Mte. Lattani (847 meters) adjoining it to the northeast. These are steep well-wooded hills, made up of solid masses of eruptive rock, with no tuffs nor signs of separate lava flows. At the eastern foot of Mte. Sta. Croce is the small town of Rocca Monfina, and extending around the two domes, especially to the east and south, is the plain of the same name. This plain (from 500 to 650 meters above sea level) is bounded by the remains of a large crater ring, which is almost circular in form and with a diameter of about 6 kilometers. At the west and south the ridge, which is called Mte. Cortinelli, is quite high and sharp, reaching its maximum elevation on the west at Mte. la Frascara (926 meters). Its inner slope is very steep, while on the exterior it is very gentle, between 6° and 10°. On the northeast and southeast the plain is bounded by a series of hills which become less high as they are farther from the center. This part of the crater ring has suffered much from erosion, being furrowed by many deep radiating ravines.

In regard to the age of the volcano Moderni says that little can be stated positively, except that at various places volcanic material is seen resting on Middle Eocene beds. Deecke notes the superposition of Rocca Monfina tuffs on the gray Campanian tuffs. It is probable that like the other volcanoes previously

[1] BUCCA, Boll. Com. Geol. Ital., 1886, 245.

[2] MODERNI, Boll. Com. Geol. Ital., 1887, 74.

[3] DEECKE, Neu. Jahrb. 1893, I, 62, 65.

described the eruptions date from the Pliocene. The date of extinction of the volcano is likewise uncertain, though probably quite recent. Some lead objects and ancient buildings, with frescoes have been found beneath the tuffs, and the date 269 B.C. has been proposed for this period— on what authority I am unable to state as Moderni's reference is inaccessible to me. Moderni however, taking into consideration the silence of the ancient writers, the want of exact data, and the liability of objects being buried by the easily transported tuff, rejects this view and leaves the question an open one.[1] The hot springs of Sujo[2] are the last symptoms of volcanic activity manifest at the present day.

Petrography.— Moderni recognizes three phases of activity in the volcano, distinguished by different products of eruption: (1) the leucitic, the oldest, which is subdivided into two sub-phases characterized by leucitites and leucite-tephrites; (2) the trachytic; (3) the basaltic, which is the youngest. As my own observations were not extended enough to enable me to judge of this point for myself I shall accept Moderni's views. The volcano is thus seen to form a notable exception to most of the composite volcanoes of Italy— the order of succession of the leucitic and non-leucitic rocks being reversed. Before entering on the petrographical descriptions it will be as well to give a brief résumé of Moderni's work.

While it is difficult to unravel certain portions of the history of the volcano one fact is certain, that the first lava erupted was leucitite. This is shown by the fact that it is found beneath all the others. The flows of this rock are the greatest in amount of any of those of the region. They form a large part of the ridge of Mte. Cortinelli, with flows at many points elsewhere round the crater ring which it is unnecessary to enumerate here. There are certain eruptive centers on the flanks of the volcano which gave vent to this type of rock, but the vast flows of the western half seem to have been poured out of the central crater. Lying above

[1] This is also the conclusion to which Daubeny comes in the second edition of his Volcanoes, London, 1848, p. 178.

[2] JOHNSTON-LAVIS, South Italian Volcanoes, Naples, 1891, 73.

the leucitites, and covering almost all the western part of the cone, are leucite-tephrites, whose amount, while great, is not equal to that of the leucitite. These also appear as small flows in the northern and eastern parts. Belonging to this period are certain tuffs, the most extensive of these being a gray lithoidal tuff which covers the flanks and extends for a great distance to the north, east, and south of the volcano. Moderni estimates that the volcano at the close of this period had an altitude of nearly 3000 meters.

The second or trachytic phase was inaugurated by the blowing out of the large central cavity, which involved the destruction of the greater part of the northern and eastern wall. It was during the first part of this phase that the double dome of Mti. Sta. Croce and Lattani was formed. These form, as already observed, a homogeneous compact mass, and are a good example of a "domal" eruption of a pasty magma which was not sufficiently fluid to flow to any great distance. The material of this eruption was of a trachy-andesite approaching the vulsinites already described, while the other eruptions of this period were of a more acid and more nearly trachytic rock and were all flank eruptions. While stating that it is impossible to decide definitely whether the central domal or the flank eruption took place first, Moderni thinks it more probable that the former was the earlier. He bases this conclusion on the ground that the large domal eruption choked up the main central vent, so that any further ejection of volcanic material had to take place through the flanks of the volcano. It is needless to mention in detail the various trachytic flows, which moreover are not nearly as large in amount as the flows of the first phase. With the trachyte there was also erupted a small quantity of leucitic rock. Several areas of trachytic tuffs also belong to this phase.

The third and last phase of activity was characterized by the eruption of basaltic rocks in which leucite is entirely wanting. These eruptions were of small amount, the quantity of basalt being even less than that of the trachytes. They formed a number of small parasitic cones, the lava poured out being often

scoriaceous. Most of these small cones were formed on the outer flanks of the volcano, but three are found in the interior, one being in the valley of Pratolungo between Mte. Sta. Croce and Mte. Lattani. The tuffs belonging to this phase are few and of small amount. That the eruption of the "basalts" was posterior to those of the leucitites and trachytes is made evident by several facts. The small cones formed by them are the best preserved of all, in many cases quite intact and covered with lapilli and bombs and with their lava flows quite bare. At Sipicciano on the northwest flank of Mte. Cortinelli a basaltic flow covers the leucitites and leucite-tephrites; while in the central eruption at Pratolungo the flow of "basalt" is seen to be superposed on the trachy-andesite of Mte. Lattani.

Leucitite.—This is represented by only one specimen in my collection, from a flow below Preta, on the outer northern side of the volcano. This shows a very compact, fine grained, dark gray groundmass, through which are scattered many small but quite glassy leucites, with rare specks of augite. In thin sections these large leucites are seen to be perfectly clear, and they show very weak double refraction for such large fresh crystals. Over the greater part of their area they carry almost no inclusions, but at the edge of almost all is a very narrow peripheral line of small augite microlites, which in turn is surrounded by a narrow mantle of leucite. This shades into the groundmass, and is quite analogous to the alkali feldspar mantles so frequently noticed in the preceding papers. Apart from the leucites only rare light green augite phenocrysts are seen, which also carry no inclusions.

The groundmass is fine grained and composed essentially of small leucites with interestitial greenish gray augite prisms and anhedra and a little magnetite. These small crystals are imbedded in a colorless isotropic substance. It is possible that this is glass, but, judging from the leucitic mantles around the leucite phenocrysts and from the fact that there is no difference in refractive index between this base and the small leucites, it seems probable that it is leucite. It would thus correspond to the nepheline base of certain phonolites and other nepheline rocks, such

as have been noticed previously. A very few flakes of alkali feldspar are also met with.

Leucite-tephrite.—One specimen of this rock was collected at Mte. San. Antonio (707 meters high), which forms one of the girdle of hills around the plain and lies due north of Mte. Lattani. The rock shows a fine grained gray groundmass in which, with the exception of very rare augites, the only phenocrysts visible are leucites. These are extremely abundant, making up a large portion of the rock. They are apparently fresh, with a waxy luster; the smaller ones pale gray, while the larger show a core of dark gray and an outer shell of light gray. This rock is extremely tough. In thin sections the large leucites are very prominent. They are clear and show strong double refraction. Inclusions are abundant, of small crystals of anorthite and green augite. They include also many small slender needles of diopside, minute grains of magnetite and spots of glass, which are very commonly clustered toward the center of the crystal, thus accounting for the dark gray cores. Beside the leucites only one or two dark green augite phenocrysts were seen in the slides. The groundmass is composed largely of irregularly shaped greenish yellow augite grains, a few small leucites, considerable magnetite, many small crystals of a plagioclase which is shown by its extinction angles to be anorthite, and some small flakes and laths of alkali feldspar. A little residual glass is also present.

A peculiar leucite-tephrite is that, from what appeared to be a small flow on the road to Conca, below Orchi. It is very dark gray and fine grained, but rather rough in texture. A few phenocrysts of augite and leucite are visible. Under the microscope it shows the doleritic structure which is so common to the Italian leucite-tephrites. None of the phenocrysts were met with in the single section which was made of this rock. In the groundmass stout columnar, pale green augites are very abundant, the largest showing cores of darker green; while these are clear and contain few inclusions (of magnetite and glass), their outlines are very irregular, most of the prisms showing deep embayments due to corrosion. A little brown barkevikitic amphibole and a few

flakes of brown biotite are also present. There are also numerous grains of magnetite and a few apatite needles.

Leucite is present in abundance, but shows an unusual habit. While often in the form of small, rounded or trapezohedral crystals, it generally occurs in irregularly shaped masses, occasionally showing crystal planes here and there, or with small, definitely shaped crystals attached to the larger mass. These leucites are extremely clear, and show a remarkably faint double refraction. Indeed so faint is the action of these leucites on polarized light, that in most of the crystals recourse must be had to the quartz wedge before any such action can be perceived, a proceeding not often necessary in the Italian leucitic rocks.

Later than the leucites, and often enclosing them micropoikilitically,[1] are flakes and large patches of a plagioclase with generally well developed twinning lamellæ, whose high symmetrical extinction angles refer it to anorthite. There are also some patches of a feldspar, which, though not showing any signs of twinning, may also be referred to anorthite on the ground of the equality of its refraction with that of the striated anorthite. There is also considerable colorless base, which, while in general isotropic, shows in places a very faint double refraction. Since treatment of the powdered rock with acids produces abundant gelatinous silica, this base may be regarded as nepheline, or at least as a glass corresponding to nepheline in chemical composition. An analysis of this rock made for me by Dr. A. Röling of Leipzig is here inserted:

SiO_2	47.40
Al_2O_3	19.84
Fe_2O_3	2.72
FeO	4.40
MgO	4.23
CaO	9.88
Na_2O	2.93
K_2O	5.91
H_2O	1.66
TiO_2	0.30
	99.27

[1] The marked difference in refractive indices between the leucite and anorthite serve to bring the structure out very nicely in ordinary light, while the dark spots of

A leucite-tephrite from Mte. San Antonio is described by vom Rath,[1] which seems to be more like the Conca tephrite than the other just described. Megascopically only few phenocrysts of augite, leucite and feldspar are visible, while under the microscope the groundmass resembles that of many leucitites already described. Sanidine phenocrysts are few, but smaller ones of plagioclose are abundant. Vom Rath's analysis is inserted here:

SiO^2	58.48
Al_2O_3	19.56
FeO	4.99
MgO	0.53
CaO	2.60
Na_2O	3.14
K_2O	10.47
H_2O	0.24
	100.01

Leucite-trachyte.—The occurrences of this rock which I observed seemed to belong to the second (trachytic) phase of the volcano, though on this point I cannot speak with certainty. My specimens may be referred to two different varieties, an augitic and a biotitic. To the former belongs the rock of a well marked flow at Acqua Rotta, about a kilometer and a half northwest of Teano. The groundmass of this is very compact and fine grained, and of a dark gray color. Leucite phenocrysts are not abundant, but many small black augites and a few flakes of biotite are visible. Under the microscope a few large leucite sections met with are clear, with quite strong double refraction, and show few inclusions. The pale green augite phenocrysts are clear, carry inclusions of magnetite, especially toward the edges, and generally show corroded outlines. The biotites present are all altered to an almost opaque, finely granular mass of augite and magnetite, generally to such an extent that but little of the original mineral remains. The groundmass resembles that of many leucitites, being composed largely of small round leucites,

leucite show out with striking clearness against the background of bright anorthite between crossed nicols.

[1] VOM RATH, op. cit. 243.

with interstitial prisms of green augite, many magnetite grains, and flakes and laths of alkali feldspar. Some larger crystals of anorthite are also seen. No glass seems to be present.

To the biotite-leucite-trachytes belong specimens from Tuoro west of Acqua Rotta, and from below Orchi on the northern flank of the volcano. Their groundmass is lighter gray than that of the preceding, small leucite and augite phenocrysts are not very common, but there is an abundance of flakes of biotite of a dark brown color and bronzy luster. In thin section they very much resemble the preceding. Augite phenocrysts are, however, rare, their place being taken by biotite. In the rock from Tuoro its color is of a deep orange red, while in that from Orchi it is much paler. It is much altered at the edges to the usual fine grained aggregate. In the groundmass of the former the alkali feldspar is in the form of laths, in the latter it is rather in the form of flakes and interstitial cement. Some basic plagioclase is present, but in small amount.

A rock which occupies a position between the above and the following group is represented by a specimen also from below Orchi. Megascopically this closely resembles the other, the only important difference being that here leucite phenocrysts are entirely wanting, and replaced by glassy sanidines. There is also considerable augite along with the biotite. The rock in thin section resembles more one of the vulsinites to be described presently than a leucite-trachyte. The sanidine phenocrysts are rarely met with. Large greenish gray augites are not uncommon, which carry inclusions of brown glass and magnetite and are somewhat corroded. The biotites are all profoundly altered, usually so much so that the crystal is almost completely disintegrated. The groundmass is made up of flakes and laths of an alkali feldspar, with a considerable number of laths and basic plagioclase which are usually surrounded by mantles of orientated alkali feldspar. Small grayish green irregularly shaped and corroded augite crystals with magnetite grains are common. There are also present many small round spots of leucite, recognized by their characteristic inclusions and by their analogies

with other occurrences. A scanty glassy base is also present. No nepheline was detected in any of the above rocks.

Biotite-vulsinite.—In the descriptions of the volcanic centers which form the subject of the preceding papers we have had occasion to examine certain members of a group of effusive rocks which, both chemically and mineralogically, stand in a position intermediate between the trachytes and the andesites. The Rocca Monfina region resembles the others in furnishing—and very prominently—members of this group. We find here in fact effusive rocks showing the mineral combination of alkali feldspar and basic plagioclase, which approximate closely to the ciminite of the Viterbo region in chemical composition. Mineralogically, however, they come closer to vulsinite of Lake Bolsena, no olivine being present, but augite and especially *biotite* being abundant representatives of the ferromagnesian minerals. So much indeed do they resemble vulsinite that they were considered at first to belong to this group, forming a species which would be called a biotite-vulsinite, as was briefly noticed in the paper on the Bolsena Region.[1] A chemical analysis, however, which I completed after the printing of that article and which will be found on page 252, shows that this determination is not quite correct. It will be seen that the silica is notably lower than in the vulsinites, and furthermore that lime, magnesia and iron are very much higher, while the alkalies are considerably lower. Comparison with the analysis of the Viterbo ciminite (which is inserted for convenience) will show that the trio are *chemically* almost identical. We have then a rock which is chemically a ciminite and mineralogically, a biotite-vulsinite.

In regard to the name by which they should be called there may be some doubt. From a mineralogical standpoint they are obviously not ciminite, nor chemically can they strictly be called vulsinite. Since, however, in the schemes of classification in general use at the present time, the mineralogical composition takes precedence over the chemical, and bearing in mind the unadvisability of adding new names to the already

[1] JOUR. OF GEOL., IV, pp. 551–553, 1896.

overburdened nomenclature, I shall designate these rocks as *biotite-vulsinite*.

The most important occurrence of biotite-vulsinite is that of Mti. Sta. Croce and Lattani, which are, as far as can be seen, entirely formed by a domal eruption of the rock just noted. This was called "trachy-dolerite" by Abich,[1] he considering it a link intermediate between trachyte and dolerite, while Pilla and von Rath consider it a trachyte. Bucca calls it an augite-andesite, and refers the greater part, if not all, of the feldspar to plagioclase. Otherwise his description agrees closely with mine.

The Santa Croce rock is trachytic in appearance, having a fine grained, but not very compact, light gray groundmass of a slightly reddish tone. Through this are scattered very many small, dark brown flakes of biotite, some small augites, and a few small feldspars. The groundmass of the Mte. Lattani rock is rather darker and of a bluish gray color, more compact, biotite flakes are less abundant, and feldspars more common. My specimen of this latter is not quite fresh. In thin section the feldspar phenocrysts are quite common. They consist of an alkali feldspar, apparently a soda-orthoclase, and a larger number of plagioclase, which is shown by its extinction angles to have the composition Ab_2An_3. These are well shaped, but contain many inclusions of glass with small opaque grains and augite microlites. The biotites are of a greenish brown color, quite fresh in the interior, but surrounded by a thin alteration border of fine augite and magnetite grains. The large, irregularly shaped augites are pale green. The groundmass is trachytic in character and shows well-marked flow structure. There is an abundance of small laths, chiefly of alkali feldspar, with some of plagioclase. Magnetite grains and small diopside microlites are present in abundance, and there is a residue base of alkali feldspar.

The rock of Mte. Lattani closely resembles the above, though there are certain differences, the rather more abundant feldspar-phenocrysts are identical, as is also the augite. The biotites are,

[1] ABICH, Vulk. Ersch., Brunswich, 1841, 100.

however, all completely, or almost completely, altered, the product being rather coarsely granular. The grains are very slightly coherent with one another, and show in a very striking way the distribution of such augite and magnetite grains through the groundmass of certain rocks, as has been already pointed out.[1] The groundmass is holocrystalline, and composed largely of flakes of alkali feldspar, with few laths. The augite and magnetite grains resulting from the disintegration of the biotite are very abundant. Bucca refers this Mte. Lattani rock to the trachytes, though, as will presently be seen, he is struck by their andeistic character.

An analysis of the rock of Mte. Santa Croce (I) made by myself is given below, II being an analysis of the same occurrence by vom Rath,[2] and III being an analysis of the ciminite of Fontenu Fiesole, near Viterbo,[3] inserted for convenient comparison.

Abich (p. 114) gives the silica percentage as 57.41 and the specific gravity as 2.79.

	I	II	III
SiO_2	55.69	55.08	55.44
Al_2O_3	19.08	17.25	18.60
Fe_2O_3	4.07	—	2.09
FeO	3.26	9.33	4.48
MgO	3.41	2.77	4.75
CaO	6.87	7.34	6.76
Na_2O	2.89	1.86	1.79
K_2O	4.41	5.32	6.63
H_2O	0.17	0.17	0.25
TiO_2	tr.	—	0.16
P_2O_5	—	—	tr.
MnO	tr.	—	—
	99.85	99.12	100.75
Sp. gr.		2.713	

Belonging to the same group is a specimen from a flow met with in the valley east of Casi, to the west of Teano. This is a

[1] Cf. JOUR. OF GEOL., IV, 270, 1896.

[2] VOM RATH, Zeit. d. d. geol. Ges., XXV, 245, 1873.

[3] H. S. WASHINGTON, JOUR. OF GEOL., IV, ——, 1896.

medium gray compact rock showing small biotite, augite, and feldspar phenocrysts. In thin sections the phenocrysts of alkali-feldspar and basic plagioclase are present in about equal amounts. They contain many glass inclusions. The biotite phenocrysts are all deeply altered, and a few large augites met with show no noteworthy features. The groundmass is trachytic and composed of flakes and laths of alkali feldspar, with laths of plagioclase, diopside needles, and magnetite grains. There is little or no glass present.

Rocks which represent transitional forms between the above and true trachytes are found in specimens from the ravine at Molino di Casa Fredda, from a flow northwest of Tuoro, near Teano, and from a loose block in the valley of Casi. They resemble the rocks already described, but plagioclase is much less abundant, and in some almost entirely wanting. The groundmass of the Casi rock is much darker and finer grained than in the other cases; feldspar phenocrysts are abundant, but few of ferromagnesian minerals are seen. Some good examples of microperthite seen in it indicate that the alkali feldspar contains considerable soda. In the specimen from Tuoro a noteworthy feature is the presence in one slide of a single, large, well-shaped crystal of colorless diallage, showing its characteristic dusty inclusions and parting parallel to the orthopinacoid These, as well as other rocks similar to these, are all described by Bucca under the head of trachytes, his descriptions agreeing very closely with the characters of my specimens. He closes, however, with the significant remark (p. 257) that they "approach so closely to the andesites that I was tempted several times to refer them to these."

Trachyte.—A rock from a small quarry on the road to Conca, on the northern outer flank of the volcano, belongs to the trachytes proper rather than the vulsinites. It is the same as a rock described by Bucca (p. 255), whose description agrees very well with the characters of my specimens. The main mass of the rock is compact and light gray, showing few phenocrysts of augite and feldspar. Scattered through this are rounded

black masses, which often attain diameters of five centimeters. These are coarsely crystalline and not very compact, with miarolitic and vesicular cavities. Under the microscope the only phenocrysts visible are of pyroxene. These are usually well formed, but occasionally quite fragmentary. The interior consists of a colorless diopside, which is uniformly surrounded by a rather narrow border of yellowish green non-pleochroic augite. The substance of this border corresponds exactly with that of the small groundmass augites, so that it is due to the same late period of growth to which they belong. The large augites are hence a good instance of the growth and enlargement of crystals brought up from below by the late accretion of isomorphous substance of somewhat different composition. Apart from the not very abundant small augites and magnetites, the groundmass is made up of feldspar and some residual glass. The feldspar forms laths with somewhat ragged edges, and they, with the augites, show well-marked flow structure. The greater part of these laths are of orthoclase, or at least an alkali feldspar; only very few showing twinning striations and extinctions which would refer them to plagioclase. No suitable sections of these latter were found by which their approximate composition could be determined, though I am inclined to think that they belong to the middle of the plagioclase series rather than to the basic end. The powdered rock, on treatment with acids, furnishes abundant gelatinous silica, which probably comes from the glass base. The dark spots referred to above are seen under the microscope to be holocrystalline, and composed of a few large diopsides with augite borders and very many smaller prismatic augites lying in a cement of orthoclase or alkali feldspar. The line of junction with the surrounding rock is quite sharp. They are true segregations and are to be classed with the *enclaves homœogènes* of Lacroix.[1]

Bucca also mentions briefly the rock of Mte. Ofelio, near Sessa, on the southwest flank of the volcano, as a true trachyte. It seems to be much decomposed.

[1] LACROIX, Enclaves des Roches, Macon, 1893, 8.

Basalt.—Of the rocks of this class described by Moderni and Bucca, I was unfortunately unable to obtain specimens. This is the more to be regretted, inasmuch as the feldspar basalts are only sparingly represented along the main line of Italian volcanoes, and at Rocco Monfina they are, according to Moderni, the last product of volcanic activity. Bucca describes a number of them, and his observations may be summarized here so as to complete as far as is possible, the petrographical description of the region.

The basalts of the region are apparently quite feldspathic, and are quite free from leucite or nepheline. In the majority of cases they are olivine-bearing, this mineral being generally phenocrystic, and seldom forming part of the groundmass. It is usually somewhat altered, especially on the borders, to a dark red substance. A few specimens are free from olivine and approach the augite-andesites, but are classed by Bucca with the basalts on account of their basic character. These last are of a light gray color, while the olivine basalts are dark. Augite is abundant, of a slightly bluish green, and not pleochroic. In two specimens a dark reddish brown biotite is present, which is for the most part largely altered to the usual augite-magnetite aggregate. The plane of the optic axes is perpendicular to the plane of symmetry. Feldspar which is referred to plagioclase rarely appears as phenocrysts, but is abundant as laths in the groundmass. Its optical characters are not noted, so that we are unable to judge of its place in the series. Small magnetite grains are abundant and a colorless glass base is usually present.

Although Bucca constantly refers to the feldspar as plagioclase, yet he does not mention twinning lamellæ, and indeed treats it in a rather cursory way. Certain facts, indeed, incline me to the belief that there is some, if not quite a good deal, of orthoclase in the rock. In the first place all the rocks which I have examined from this and the other volcanic centers are eminently rich in potash, even the phonolite of Viterbo containing 9.14 per cent. of it. It would then be quite anomalous to find here such a rock as a normal basalt containing a mini-

mum amount of this alkali. If the feldspar is all plagioclase, as Bucca's description would indicate, there would be no mineral capable of taking up any notable amount of potash, as its percentage in biotite is never over 10., and the amount of this mineral in these rocks is small.

Furthermore we find at Radicofani, which is on the same main line, "basalts" containing very considerable orthoclase along with the plagioclase, and showing in one instance: $SiO_2 = 55.13$; $K_2O = 2.43$, and $Na_2O = 2.07$. Again Abich (*op. cit.* page 114) gives the silica percentage of the "basalt" from the foot of Santa Croce as 54.62, and classes it as a trachy-dolerite, though a rather basic one resembling the dolerites, while the rock of Monte Santa Croce is more acid and like the trachytes. It seems then very probable that these "basalts" of Rocca Monfina are in reality not normal plagioclase basalts, but rather approach the ciminites in composition both mineralogically and chemically.

HENRY S. WASHINGTON.